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Impact of Conjuctive Use of Inorganic phosphorus and Biofertilizers on Nutrient Content of Maize in Sandy Clay Soil

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ABSTRACT

Nutrient contents of a study was carriedout to evaluate the influence application of different levels of phosphorus fertilizer along with biofertilizers during *Rabi* 2022 at Agricultural College Farm, Bapatla. The experiment was laidout in randomized block design with eight treatments comprosing of T_1: Control (0% RDP), T_2: 50% RDP, T_3: 75% RDP, T_4: 100% RDP, T_5: PSB +VAM, T_6: 50% RDP+ PSB + VAM, T_7: 75% RDP+ PSB + VAM, T_8: 100% RDP+ PSB + VAM. The plant samples collected at flowering and harvest were analysed for N, P, K and micronutrients by standard procedures. The results of the experiment indicated that P and Zn were significantly influenced by the imposed treatments whereas N, K, Fe, Mn, Cu were not significantly influenced. The highest nutrient content was recorded in the treatment 100% RDP + PSB + VAM (T_8) and it is on par with 75% RDP + PSB + VAM (T_7). So, the results indicated that the combined application of inorganic fertilizer and biofertilizer improved the nutrient content in maize significantly over control and biofertilizers alone.

Keywords: *Biofertilizers,Inorganic fertilizers,Maize,Nutrient content and Plant samples.*

Maize (*Zea mays* L.) is the most versatile crop among cereals with respect to its adaptability, types and uses. It is the second most widely grown crop in the world and cultivated in tropics, sub-tropics to temperate climate. Maize is globally also known as "Queen of cereals" and grower's interest towards maize has been increasing due to its high production potential, wider flexibility under different climatic and soil conditions and variety of industrial uses, growing weird weather patterns and inadequate supply of water for rice cultivation. Currently, 1210 million tonnes of maize is being produced together by over 170 countries from an area of 205 million hectares with an average productivity of 5.87 t ha^{-1} (FAOSTAT, 2021). The global consumption pattern of maize is 61%, 17% and 22% as feed, food and industry, respectively. In India, maize is grown in an area of 10.04 m ha of land in India, with a production of 33.62 million tonnes and productivity of 2689 kg ha^{-1} (agricoop.nic.in, 2022). In Andhra Pradesh, maize is cultivated in an area of 3.42 lakh ha with a production of 20.49 lakh tonnes and productivity of 5991 kg ha^{-1} accounting for 6.09 per cent of the country's total production (des.ap.gov.in, 2021-22).

Biofertilizers are most likely called bio-inoculants as their preparations contain living or latent cells of micro-organisms that help the plants as nutrient uplake by their interactions within the rhizosphere once applied through the seed or soil (Bahadur *et al*., 2006). They also help to reduce the adverse effects of the excessive and imbalanced use of chemical fertilizers which can reduce the chemical fertilizer dose by 25-50% (Pattanayak*et al*., 2007)

MATERIAL AND METHODS

A field experiment was conducted at Agricultural College Farm, Agricultural College, Bapatla during *Rabi,* 2022. NMH-8352 Winner was seeded on sandy clay soil with a spacing of 60cm×20cm in randomized block design with three replications. The experimental soil was sandy clay in texture, non-calcareous, slightly alkaline, non-saline, medium in organic carbon, low in available nitrogen, high in available phosphorus and available potassium and sufficient in micro nutrients *viz.* Zn, Fe, Mn and Cu. The experiment was carried with ten treatments *viz*., T_1: Control, T_2: 50% RDP, T_3: 75% RDP, T_4: 100% RDP, T_5: PSB +VAM, T_6: 50% RDP+ PSB + VAM, T_7: 75% RDP+ PSB + VAM, T_8: 100% RDP+ PSB + VAM. Well decomposed farmyard

manure @ 10 t ha^{-1} was applied 10 days before sowing. Recommended dose of nitrogen, phosphorus and potassium were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Recommended dose of nitrogen @ 220 kg ha^{-1} and potassium @ 80 kg ha^{-1} were applied uniformly to all the plots. Recommended dose of P_2O_5 @ 80kg ha^{-1} was applied as per the treatments as basal just before sowing. Nitrogen was applied in four equal splits (¼ each at the time of sowing, knee high, between knee high-tasseling and tasseling stages). Potassium was applied in two splits (½ at the time of sowing and the remaining ½ at the time of tasseling stage). Farmyard manure was mixed with biofertilizers *viz.,* PSB@ 1.25 L ha^{-1} and VAM @ 12.5 kg ha^{-1} as per the treatments. Recommended cultural practices and plant protection measures were taken throughout the cropping season.

Collection and preparation of plant samples

The plant samples collected at flowering and harvest stages were washed with dilute HCl and then with distilled water. The samples were shade dried initially and then oven-dried at 65^0C temperature and powdered in Willey mill. All the parameters were analysed by adopting suitable standard procedures

Plant analysis

Nitrogen

The nitrogen content in sorghum plants was estimated by the micro Kjeldahl distillation method (Piper, 1966) and the results are expressed in percentage.

Preparation of acid extract by wet digestion

One gram of powdered plant sample was taken in 150 mL Erlenmeyer flask and digested with di-acid mixture (HNO_3 and $HClO_4$ in 9: 4 ratio). The sample digest was filtered through Whatman No.42 filter paper by washing the residue with double glass distilled water till chloride-free and made up to 100 mL volume and the clear extract was used for the determination of P, K, Fe, Zn, Cu and Mn.

Phosphorus

Phosphorus in the di-acid extract of plant samples was estimated by Vanadomolybdo phosphoric yellow colour method using a spectrophotometer at 420 nm wavelengths as described by Tandon (2009) and the results expressed in percentage.

Potassium

Potassium in the di-acid extract of plant samples was determined using a flame photometer as per the method described by Tandon (2009) and the results are expressed in percentage.

Micronutrients

Zinc, copper, manganese, and iron in the di-acid extract were determined using atomic absorption spectrophotometer as per the specifications mentioned by Lindsay and Norvell (1978) and the results expressed in mg kg^{-1}.

All the data recorded in the study were subjected to statistical analysis using Panse and Sukhatme(1978) . Statistical significance was tested by applying F-test at 0.05 level of probability and critical differences were calculated for those parameters, which were found significant (pÂ0.05) to compare the effects of different treatments.

RESULTS AND DISCUSSION

The data recorded on content of different nutrient in sorghum plants at harvest stage of crop indicated that the treatmental effects were significant only with phosphorus and zinc while, other nutrients were not significantly influenced.

Nitrogen

Nitrogen content in maize at tasseling and harvest stages furnished in the table 1 indicated that application of different levels of inorganic phosphorus fertilizers along with biofertilizers did not show the significant difference on content of nitrogen.

The treatment received 100% RDP + PSB + VAM(T_8) recorded the highest nitrogen content at tasseling (2.26%) and harvest in grain (1.72%) and stover (0.73%), followed by 75% RDP+ PSB + VAM(T_7) with nitrogen content at tasseling (2.22%) and harvest (1.71%) and (0.67%) in grain respectively). The lowest nitrogen content was recorded in control (0% RDP) (T_1) at tasseling (2.06%) and at harvest (1.54% and 0.54% in grain and stover, respectively). With increasing levels of phosphorus the nitrogen content increases this might be ascribed to the positive effect of phosphorus on cell division, increased root hairs and root elongation

of plant through which it may explore wider area for nutrient absorption leading to higher nutrient concentration in plant (Das *et al*., 1989).

Phosphorus

The data presented in table 2 and illustrated in figure 1 related to the phosphorus content in maize plant, at tasseling and harvest stages indicated that there was a significant difference among the treatments with the application of different levels of inorganic phosphorus fertilizer, and bio-inoculants.

Perusal of data revealed that the treatment that received 100% RDP + PSB + VAM(T_8) recorded significantly highest P content at tasseling (1.30%) and harvest in grain (0.96%) and stover (0.51%), followed by 75% RDP + PSB + VAM(T_7) with P content values at tasseling (1.23%) and at harvest (0.94 and 0.47 % in grain and stover, respectively).

The significantly lowest P content was recorded in control (0% RDP) (T_1) at tasseling (1.11%) and at harvest (0.70 and 0.38% in grain and stover, respectively) Phosphorus concentration was found to be significantly higher in maize plants treated with inorganic P and biofertilizers compared to the control plants. As a result, P uptake was significantly increased in kernel and stover. Phosphorus concentration tended to increase as phosphorus fertilizer levels were increased. Increasing phosphorus level from 0 up to 60 kg, P_2O_5 ha^{-1} significantly increased phosphorus in maize kernel and stover (Gahukar*et al*. 2011).

Phosphorus plays a very important role in photosynthesis as it is crucial for activation of ribulose-1,5-bisphosphate carboxylase oxygenase (Rubisco) and in providing phosphorylated intermediates of Calvin cycle (Hernández and Munne-Bosch, 2015). The inoculation with PSB helps in releasing phosphorus from native and also protecting fixation of phosphate by excretion of organic acids and enzymes, some of the hydroxy acid (organic acid) may form chelates with cation as Ca^{2+} and Fe^{2+} which resulted in effective solubilization of phosphates and rendered more available phosphorus for the plants leading to increased P content of the plant. The results are corroborative of the findings of Satpal and Kapoor (1992).

Potassium

Potassium content was assessed during tasseling and harvest stages of the maize crop and the data pertaining to content of potassium presented in table 3 indicated that application of different levels of inorganic phosphorus fertilizers along with phosphorus biofertilizers did not show the significant difference on content of phosphorus at tasseling and harvest stages of maize crop.

The potassium content was found to decrease from tasseling to harvest. Further it is also interesting to note that K content was higher in stover than grain at harvesting stage of maize as compared to N and P, which indicated maize stover can be used as a source of potassium. The highest potassium content of 2.24%, 0.39% and 1.46% at tassseling, grain and stover at harvest, respectively, was observed with application of 100% RDP + PSB + VAM(T_8) and the lowest was recorded in control (0% RDP) (T_1) 2.02%, 0.30% and1.29% at tassseling, stover and kernel at harvest, respectively.

Potassium accumulation was recorded higher in VAM treated maize plants. The higher level of K accumulation in plants inoculated with AM fungi was well reported in different crops (Rajesh *et al.*, 2011: Baslam*et al*., 2013).

Zinc Content

In the present study, zinc content was assessed during tasseling and harvest stage of the maize crop and the data pertaining to content of zinc presented in table 4and depicted in figure2 indicated that application of different levels of inorganic phosphorus fertilizers along with phosphorus biofertilizers show the significant difference on content of zinc at tasseling stage and harvest of maize crop. The maximum zinc content (34.9, 23.9, 29.6 mg kg^{-1}) at tasseling, grain and stover at harvest stage was recorded in control (0% RDP) (T_1) followed by 50% RDP(T_2)(33.0, 22.1 and 27.4 mg kg^{-1}). The minimum zinc content (29.2, 18.7 and 23.5 mg kg^{-1}) was recorded with treatment 100% RDP+ PSB + VAM(T_8). Zinc content significantly decreased with increasing P levels. Inderpalsingh *et al*., (2017) found that in grain, Zn content significantly decreased with increase in the P levels from P_{10} to P_{30}. Phosphorus applications have been reported to negatively affect the shoot and even grain Zn concentration in cereal crops (Ryan*et al*., 2008). In addition, complex interactions of P with cations such as Fe and especially Zn are known to occur. Chahal and Ahluwalia (1977) indicated that Zn concentration in all the plant parts of the maize were significantly and progressively decreased with the increasing rates of P application.

Iron Content

Results revealed that variations in iron content at tasseling and in harvest stage (grain and stover) were non-significant.(Table 5)

At tasseling stage maximum iron content (74.4, 59.6 and 64.8 mg kg^{-1}) was observed in 100% RDP + PSB + VAM(T_8) followed by 75% RDP + PSB + VAM(T_7)(72.1, 58.6 and 63.5 mg kg^{-1}). The minimum iron content (67.5,47.2 and 60.4 mg kg^{-1}) was recorded with control (% RDP) (T_1) in accordance with the same findings of Jaideep *et al.* (2016).

Manganese Content

It was evident from the data in table 6 that, manganese content at different growth stages of the plant did not show any significant difference due to application of different levels inorganic phosphorus fertilizers along with phosphorus biofertilizers.

The maximum manganese content (26.2, 11.8 and 19.2 mg kg^{-1}) was recorded with application of 100% RDP+ PSB + VAM (T_8) and minimum in control (0% RDP) (T_1) with values of (23.2, 11.4 and 16.3, mg kg^{-1}) at tasseling, grain and stover at harvest, respectively. Inderpalsingh*et al*. (2017) reported that increasing levels of phosphorus to the soil did not significantly influence the manganese content in wheat grain. Amin *et al*. (2013) reported that P application had no significant effect on Mn concentrations in the roots and shoots of corn plants.

Copper Content

Copper content at both stages of crop growth was not significantly influenced by different levels of phosphorus, PSB and VAM (Table 7).

The highest copper content (8.93, 4.12 and 9.52 mg kg^{-1}) was recorded with application of 100% RDP + PSB + VAM (T_8) and the lowest in control (0% RDP) (T_1) (8.34, 3.58 and 8.02 mg kg^{-1}) at tasseling, grain and stover at harvest, respectively. The copper content in stover was more compared to kernel because of less mobility of micronutrients from stover to kernel. In accordance with the findings of Inderpalsingh*et al*., 2017, Vaghasia and Bhalu, 2016 the increasing levels of phosphorus in the soil did not significantly influence the copper content.

It was concluded that nutrient content (P) of maize at tasselling and harvest stage were higher in the treatment that received100% RDP + PSB + VAM (T_8) and it was on par with 75% RDP + PSB + VAM (T_7). The Zn content was significantly higher with treatment control (0% RDP) and it is lower in 100% RDP + PSB + VAM (T_8). The nutrient content of N, K, Fe, Mn and Cu of maize at tasselling and harvest stage were not significantly influenced by the increasing levels of phosphorus along with biofertilizers.

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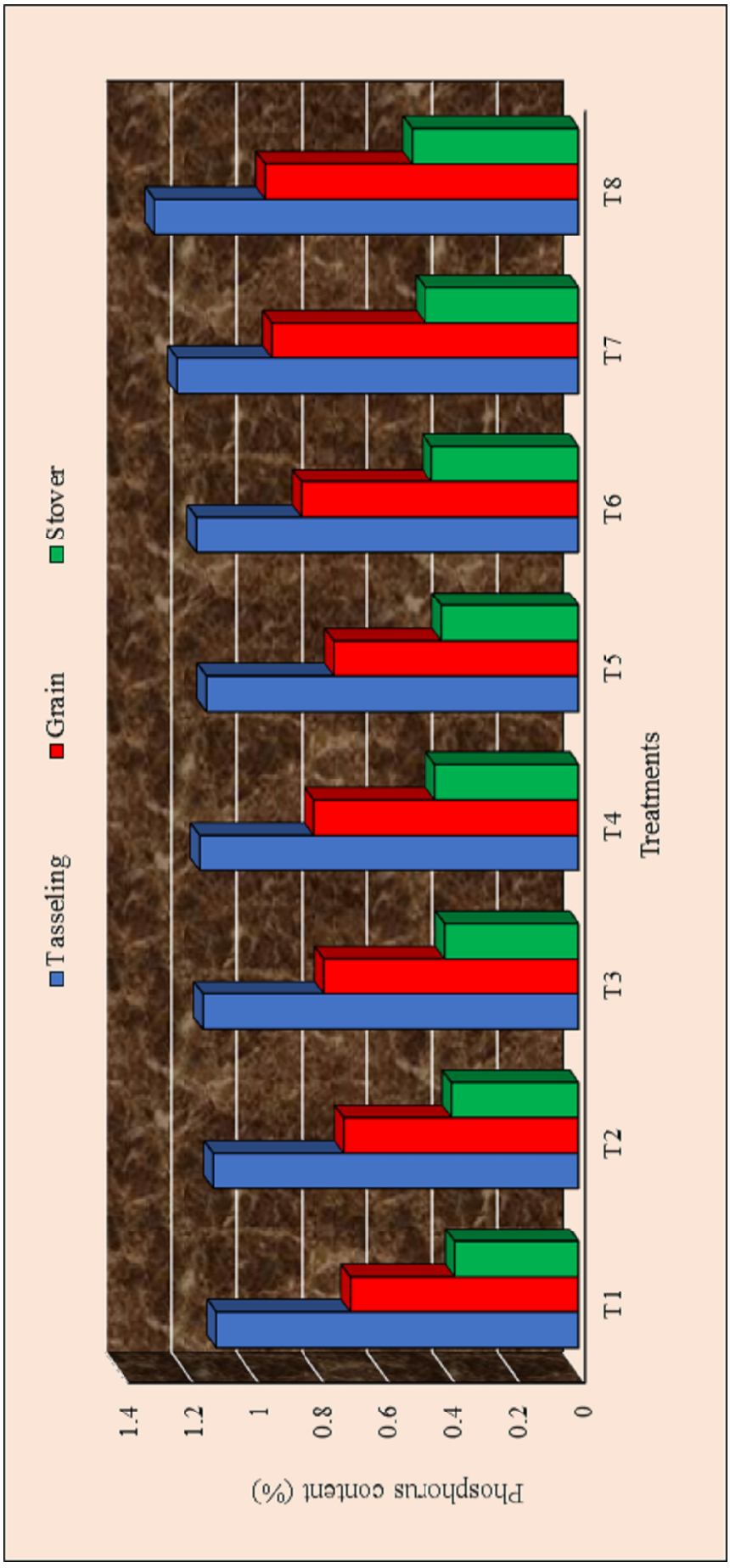

Figure 1. Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on phosphorus content (%) of maize

T_1: Control (0% RDP) T_2: 50% RDP T_3: 75% RDP T_4: 100% RDP

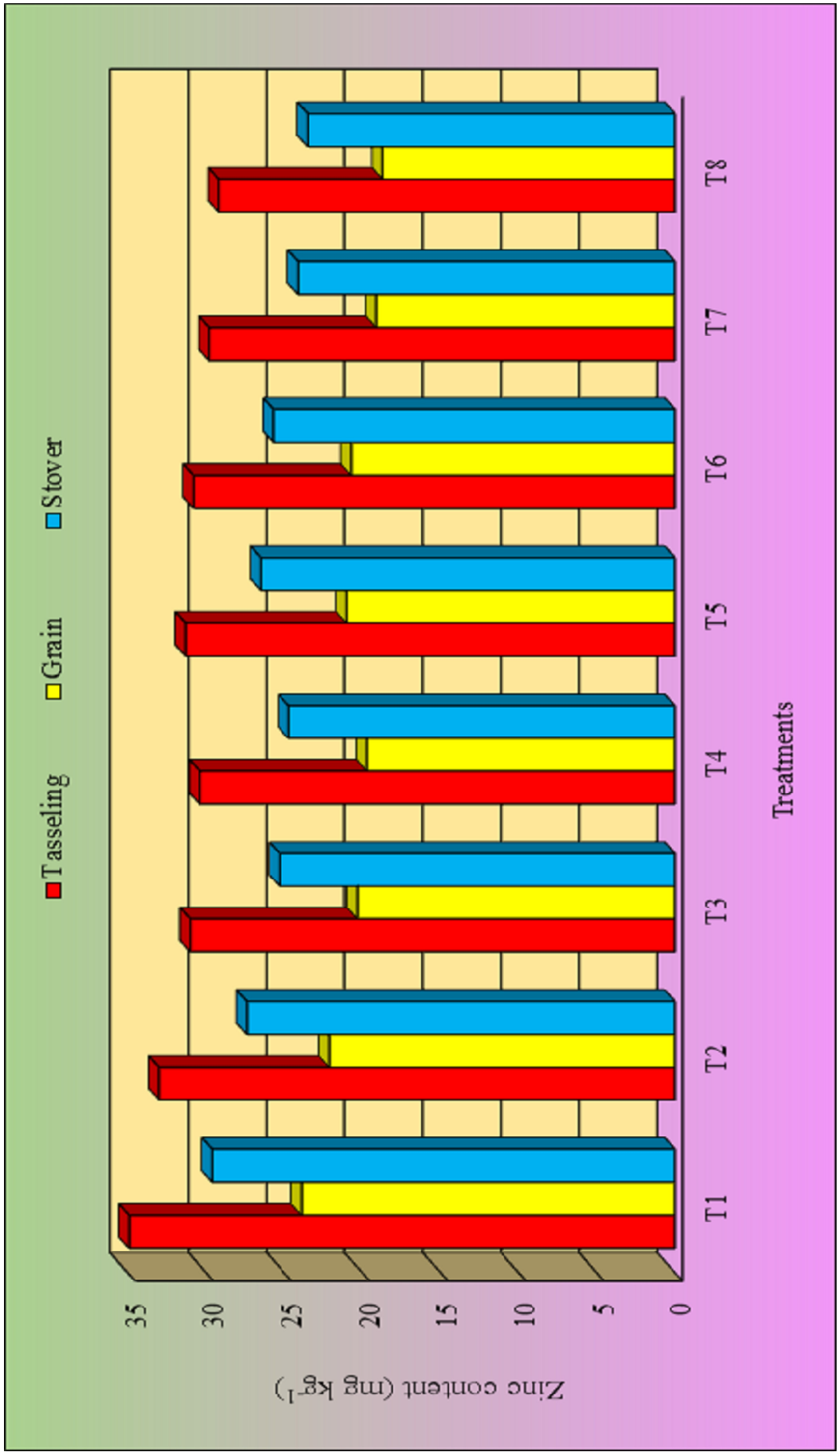

Figure 2. Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on zinc content (%) of maize

T_1: Control (0%RDP) T_2: 50% RDP T_3: 75% RDP T_4: 100% RDP

T_5: PSB +VAM T_6: 50% RDP +PSB +VAM T_7: 75% RDP +PSB +VAM T_8: 100% RDP +PSB +VAM

Table 1.Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on nitrogen, phosphorus and potassium content (%) of maize

Treatment	Nitrogen			Phosphorus			Potassium		
	Tasseling	Harvest		Tasseling	Harvest		Tasseling	Harvest	
		Grain	Stover		Grain	Stover		Grain	Stover
T_1 - Control (0% RDP)	2.06	1.54	0.54	1.11	0.70	0.38	2.02	0.30	1.29
T_2 - 50% RDP	2.08	1.57	0.52	1.12	0.72	0.39	2.06	0.31	1.32
T_3 - 75% RDP	2.14	1.64	0.54	1.15	0.78	0.41	2.15	0.32	1.40
T_4 - 100% RDP	2.20	1.69	0.62	1.16	0.81	0.44	2.16	0.35	1.43
T_5 - PSB +VAM	2.10	1.59	0.60	1.14	0.75	0.42	2.10	0.34	1.36
T_6 - 50% RDP + PSB + VAM	2.17	1.68	0.62	1.17	0.85	0.45	2.20	0.37	1.41
T_7 - 75% RDP + PSB + VAM	2.22	1.71	0.67	1.23	0.94	0.47	2.18	0.38	1.45
T_8 - 100% RDP + PSB + VAM	2.26	1.72	0.73	1.30	0.96	0.51	2.24	0.39	1.46
S.Em (±)	0.11	0.04	0.07	0.04	0.03	0.02	0.12	0.12	0.06
CD (P = 0.05%)	**NS**	**NS**	**NS**	0.13	0.10	0.05	**NS**	**NS**	**NS**
CV (%)	8.72	12.29	7.29	6.17	6.12	6.42	9.24	11.46	7.15

Table 2. Effect of phosphorus biofertilizers in combination with inorganic P fertilizers on zinc, iron, manganese and copper content (mg kg^{-1}) of maize

Treatment	zinc			Iron			Manganese			Copper		
	Tasseling	Harvest		Tasseling	Harvest		Tasseling	Harvest		Tasseling	Harvest	
		Grain	Stover		Grain	Stover		Grain	Stover		Grain	Stover
T_1 - Control (0% RDP)	34.9	23.9	29.6	67.5	47.2	60.4	23.2	11.4	16.3	8.34	3.58	8.02
T_2 - 50% RDP	33.0	22.1	27.4	68.6	48.4	60.9	23.1	11.5	16.7	8.46	3.63	8.14
T_3 - 75% RDP	31.0	20.3	25.3	69.5	55.1	61.6	24.9	11.6	17.7	8.72	3.90	8.69
T_4 - 100% RDP	30.4	19.7	24.7	70.7	57.4	62.4	25.4	11.7	17.9	8.73	4.04	8.93
T_5 - PSB +VAM	31.3	21.0	26.5	69.3	49.1	61.3	24.4	11.6	16.8	8.64	3.76	8.15
T_6 - 50% RDP + PSB + VAM	30.8	20.7	25.7	72.2	55.1	62.8	25.9	11.6	18.4	8.83	4.06	8.82
T_7 - 75% RDP + PSB + VAM	29.8	19.1	24.1	72.1	58.6	63.5	26.1	11.7	18.8	8.69	4.08	9.06
T_8 - 100% RDP + PSB + VAM	29.2	18.7	23.5	74.4	59.6	64.8	26.2	11.8	19.2	8.93	4.12	9.52
S.Em (±)	1.14	0.87	0.88	2.86	3.29	2.54	1.23	0.62	0.86	0.42	0.17	0.53
CD (P = 0.05%)	3.43	2.63	2.67	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	6.84	6.16	6.08	7.02	10.66	7.09	8.56	9.18	8.36	8.44	7.59	10.68

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